Introduction

Nervous system is not capable to innervate all the cells of the body thus another coordinating system is needed. Endocrine system fulfils this gap by chemical coordination.

A **hormone** is a "chemical messenger", secreted by an endocrine gland. Traditionally hormones have been described by scientists as the chemical products travel within the bloodstream to all parts of the body, causing an effect on specific cells or target

organs. It also affects exocrine glands or individual cell or tissue that secrete chemical substances. The glands that secrete hormones, pour directly into the blood stream are called **endocrine glands** or **ductless glands.** The glands which secrete other substances such as digestive enzymes, milk, sweat, bile and route their secretions to specific destinations by means of ducts are called **exocrine glands or ducted glands.**

18.1 Hormones- The Chemical Messengers

Path of chemical message (Hormone)

Hormones are "chemical messengers", secreted by cells that affect other cells. Hormones that travel within the blood stream and affect cells in another part of the body are known as "**endocrine hormones**". While those hormones that do not travel within the blood stream but only affect cells lying near the secretary cells are known as **"local hormones"** e.g., serotonin, prostaglandin, gastrointestinal hormones etc.

Role of Hormones

Hormones are small soluble organic molecules which are effective in low concentration and affect at a site where specific receptors are present therefore, hormone is either increase or decrease or modify the secretion of other glands. They also increase or decrease a body structure.

18.1.1 Chemical Nature of Hormones

Chemically, there are three basic types of hormones, which are:

1. Steroid
2. Amino acids or their derivatives, proteins and glycoproteins.
3. Few belong to the fatty acids e.g., prostaglandin

Steroid hormones are derivatives of cholesterol and secreted by cortex of adrenal gland (cortisol and aldosterone), testes (androgen), ovaries and placenta (estrogen and progesterone).

Pheromones

They are hormone-like chemical messengers but removed outside they body. These are small, volatile chemicals that function in communication among animals and fungi. They act by influencing the physiology and behaviour of the receiving individuals.

Amino acid derivatives are of two groups. The epinephrine and nor-epinephrine are secreted from adrenal gland, thyroxin and tri-iodothyronine (T_3), secreted by thyroid glands. All these are derivatives of tyrosine amino acid.

Polypeptide hormones are oxytocin, vasopressin, adrenocorticotrophic hormone, calcitonin, parathormone, melanocyte stimulating hormones.

Proteinaceous Hormones include somatotophic hormone, (STH) and insulin.

Extra Information

Oxytocin and antidiuretic hormones are peptide of only nine amino acids.

Glycoprotein hormones are Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH), human chorionic gonadotropin (hCG) and Thyroid stimulating hormone (TSH).

18.1.2 Mode of Hormone Action

There are two modes of action of hormones.

1. Fixed Membrane Receptor Mechanism

The peptide and protein hormones cannot pass through cell's plasma membrane because they are water soluble. Thus attached with the receptors on the plasma membrane of target cell and then start a series of steps in the cell. Adenylate cyclase is an enzyme of plasma membrane, which involved in ATP meta-bolism as catalyst, the transfo-rmation of ATP into second messenger, the **Cyclic Adenosine Monophosphate (cAMP).**

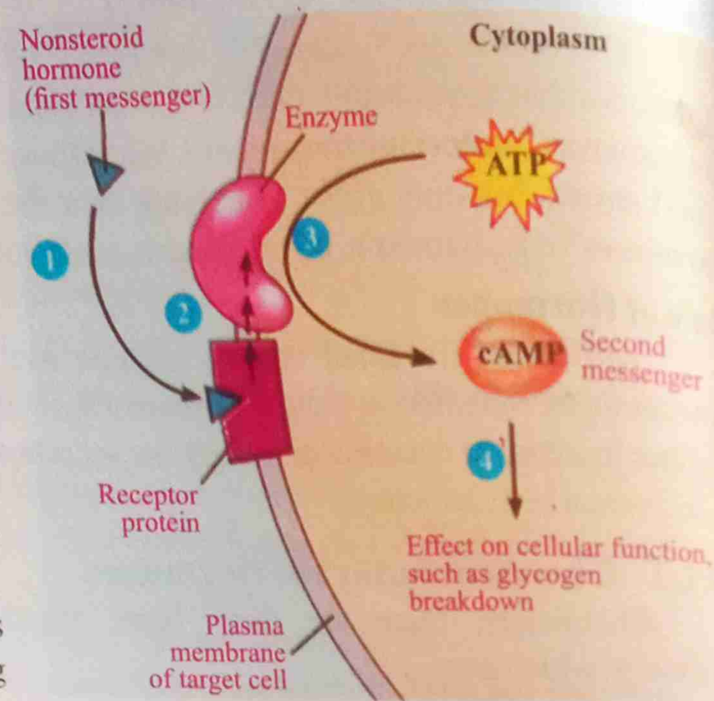

Fig. 18.1: Action of Non-steroid Hormone

The cAMP triggers various changes in the cell including activation of enzymes, gene activation (another term use to describe this entire process is called **signal transduction**). (Fig.18.1)

2. Mobile Receptor Mechanism

(Gene/signal Modulation)

The steroid and amino acid derivative hormones can easily pass through plasma membrane because both are lipid soluble. Their receptors are placed inside target cells i.e., either in cytoplasm or nucleus. These together with target receptors form hormone-receptor complex, which then travel to the particular gene, acting as transcrip-

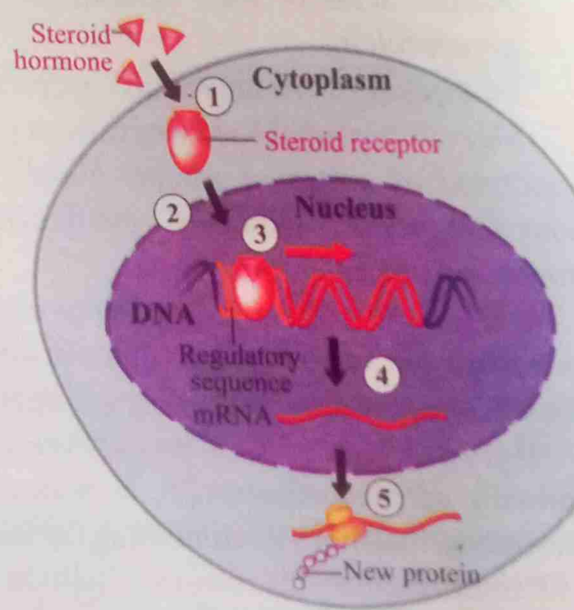

Fig. 18.2: Action of Steroid Hormone

tion factor. The target gene is transcribed into messenger RNA then it is translated into polypeptide (protein) in cytoplasm. Thus the activities of target cells are modified by the alter gene expression. (Fig.18.2)

18.2 Endocrine Glands (System) of Human

Human endocrine system includes about 20 different endocrine glands, some of which are hypothalamus, pineal, pituitary, thyroid, parathyroids thymus, adrenal, pancreatic islets and gonads. (Fig.18.3)

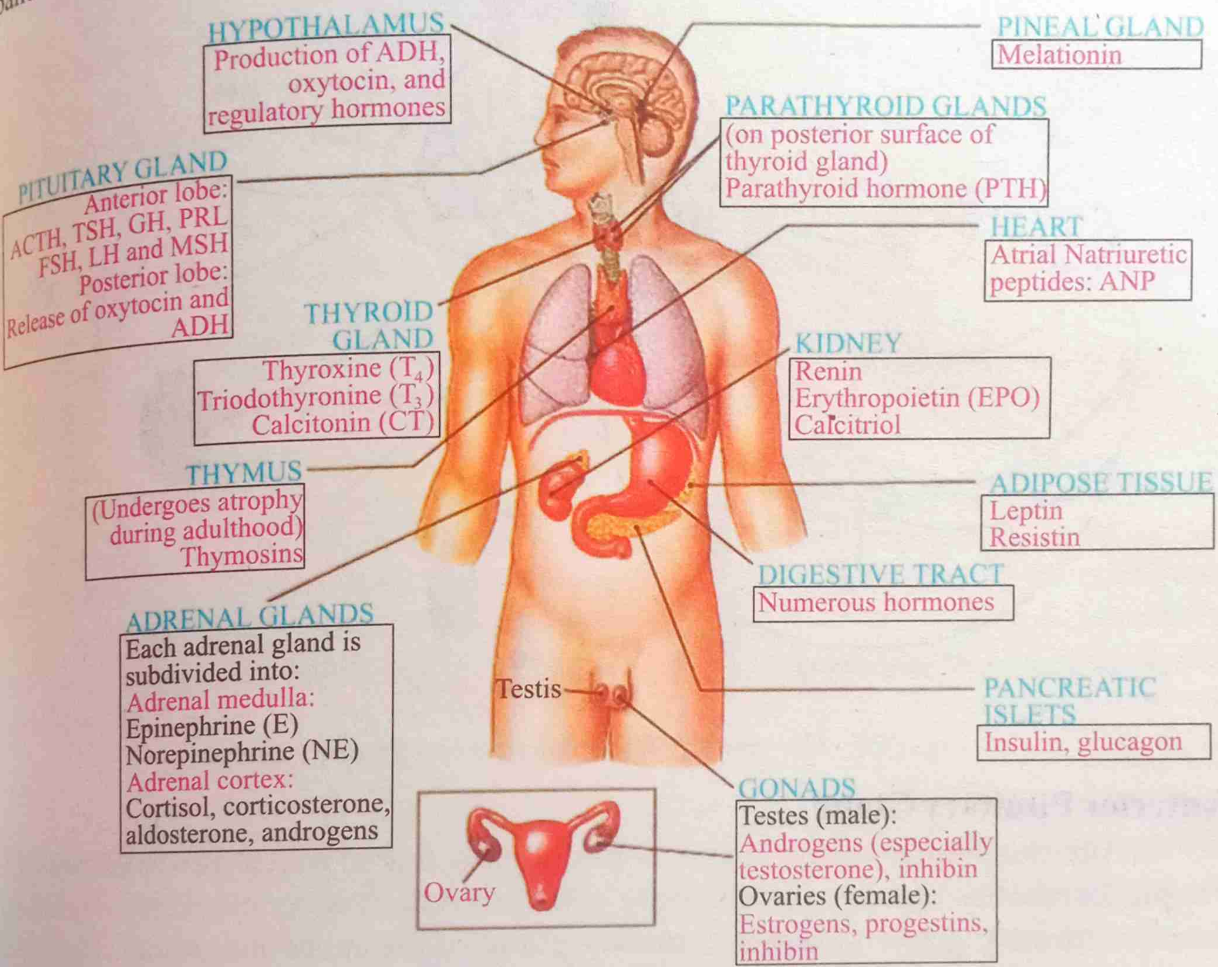

Fig. 18.3: Major Endocrine Glands

18.2.1 Pituitary Gland

Pituitary gland is small pea-sized gland, (about 0.5gram) lies in the brain. It is attached with hypothalamus by a stalk known as **infundibulum**, which is made of blood vessel and the nerve fibres of neurosecretory cells. Pituitary gland is divided into three lobes, the anterior pituitary (**adenohypophysis**), posterior pituitary gland (**neurohypophysis**) and intermediate pituitary (**Median lobe**). (Fig. 18.4)

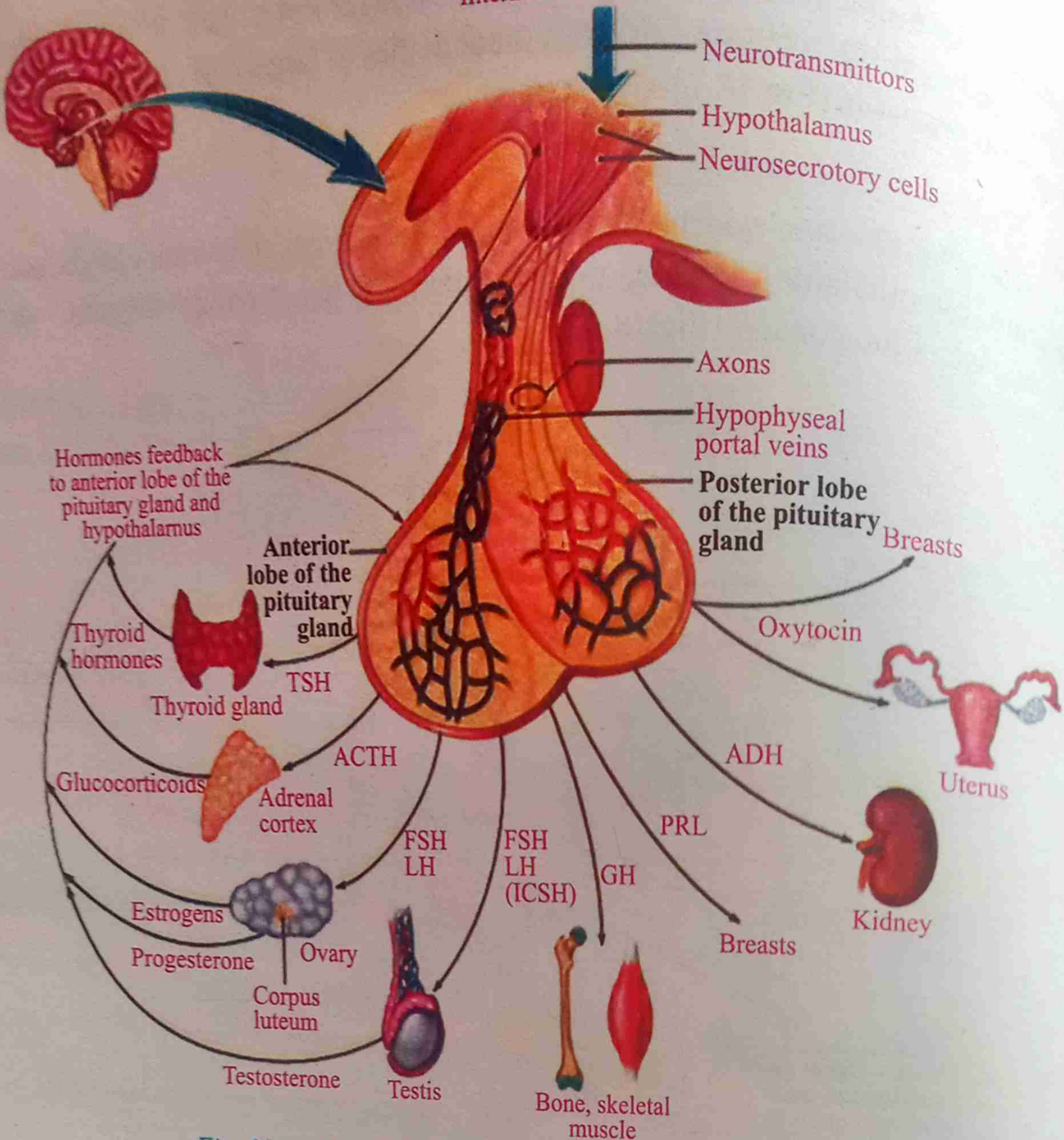

Fig. 18.4: Hormones of Hypothalamus and Pituitary Glands

Anterior Pituitary Gland

Anterior pituitary gland secretes six hormones, four of which are tropic hormones. **Tropic hormones** regulate the secretory action of other endocrine glands. Therefore, anterior pituitary gland is known as **master gland** of the endocrine system. The tropic hormones are thyroid stimulating hormone **(TSH)**, adrenocorticotropic hormone **(ACTH)**, follicles stimulating hormone **(FSH)** and luteinizing hormone **(LH)**. Other two anterior pituitary hormones are called **primary hormones**, such as growth hormone **(GH)** and prolactin **(PRL)**, these directly affect body structure or exocrine gland.

i) Growth Hormone (GH) or Somatotrophic Hormone (STH)

Its stimulating factor is **somatotropin releasing factor (SRF or GHRF),** which is secreted from hypothalamus throughout life and inhibited by hypothalamic **somatostatin** (Inhibitor Hormone).

Growth hormone has a direct effect on growth of the body, skeleton and skeletal muscle. It also stimulates cell growth and cell division, increases movement of amino acids to the cells i.e., helps in protein synthesis.

Disorders due to over secretion of GH in **early life** is called **gigantism.** It causes extraordinary elongation of bones and person becomes giant.

While in **adulthood**, the bones grow in thickness, thus enlargement of hand, feet, skull, nose and Jaw bones occur. This condition is called **acromegaly**.

Deficiency of GH leads to **pituitary dwarfism**, the development is much slower than normal. The individual has short stature, but the development of brain and Intelligence Quotient (IQ) is not affected.

ii) Thyroid Stimulating Hormone (TSH)

TSH controls the secretion and development of thyroid gland. Its secretion depends on the level of thyroxin in the blood. Hypothalamus detects the level of thyroxin, if it is less then hypothalamus secretes **thyroid releasing factor (TRF) or thyrotropin**, which in turn stimulates pituitary gland to release TSH that affects the activity of thyroid gland.

Low TSH level may be harmful for health, heart disease and osteoporosis may occur. While high TSH level in blood indicates hypothyroidism.

iii) Adrenocorticotropic Hormone (ACTH)

It acts on adrenal cortex and stimulates the secretion of **corticosteroids** (cortisone and aldosterone). The secretion of ACTH is stimulated by **adrenocorticotropic releasing factor (CRF)** from hypothalamus as a result of stress e.g., pain, cold, fear, stress, infection and pregnancy. Cushing disease is caused by a pituitary gland tumour, that over secretes the hormone ACTH, thus over stimulate adrenal cortex to secrete cortical production.

iv) Gonadotropins

Gonads are the male and female sex organs (testes/ovaries). The gonadotropins are hormones that affect these sex organs, thus considered endocrine glands because they secrete sex hormones i.e., follicle stimulating hormone and Luteinizing hormones.

Follicle Stimulating Hormone (FSH)

In human females, FSH targets the ovary and triggers the maturation of one egg (sometime more than one egg) per month. In addition, it stimulates cells in the ovaries to secrete female sex hormones called estrogen.

In males, FSH targets the testes and triggers the production of sperms. The secretion of FSH is stimulated by gonadotropin releasing hormone (GnRH) from the hypothalamus.

Luteinizing Hormone (LH)

Its secretion is also controlled by gonadotropin releasing hormone (GnRH). **In**

females a surge of LH near the middle of menstrual cycle stimulates the release of an egg from grafian follicle of ovary. In addition, LH triggers the development of cells within the rupture follicle to form a glandular structure called **corpusluteum** which secretes a hormone known as **progesterone** (to prepare uterus for coming embryo). LH is also responsible for multiple births. **In male**, LH is also known as **Interstial Cell Stimulating Hormone** (ICSH). It promotes production of the male sex hormone **testosterone.**

Low secretion of both FSH and LH leads to delay sexual maturation. The GnRH deficiency may be by birth or acquired.

Prolactin Hormone (PRL)

It works in conjunction with estrogen, progesterone and other hormones. It causes enlargement of the mammary glands and prepare them for the production of milk (lactation) after birth. It stimulates mothers to care their young ones. During the menstrual cycle, milk is not produced or secreted because prolactin level in the blood is very low. Its secretion is inhibited by **Prolactin Inhibiting Factor (PIF)** from hypothalamus.

Posterior Pituitary Lobe (Gland)

The posterior lobe of the pituitary is nonglandular, it stores and releases two hormones that are produced by the hypothalamus. These are **Antidiuretic Hormone (ADH)** and **Oxytocin**.

> ***Interesting Information***
>
> Lack of antidiuretic hormone causes "diabe-tes insipidus". As a result, there is the production of large quantity of watery urine and person feels great thirst and dehydrated.

i) Antidiuretic hormone (ADH)

It helps to regulate volume of the blood by regulating the amount of water reabsorbed by the kidneys. For example, osmoreceptors in the hypothalamus can detect a low blood volume by detecting when the solute concentration of the blood is high, then the neurosecretory cells of hypothalamus make ADH, which is transported within axon to the posterior pituitary, then releases into the blood stream. ADH binds to target cells in the collecting ducts of the nephrons of the kidneys, increasing their permeability for water reabsorption, thus urine becomes concentrated. ADH also acts on the smooth muscles surrounding arterioles, an action that helps to raise the blood pressure. Alcohol suppresses ADH release that is why excessive drinking leads to the production of excessive quantities of urine and eventually to dehydration.

ii) Oxytocin

It is also produced in hypothalamus and transported within axons to posterior pituitary for secretion. **In women,** it is secreted **during birth** process, triggered by stretching of the cervix of uterus at the beginning of the birth process, oxytocin binds to target cells of the uterus, increasing the contraction which is already taking place. It is

also used artificially to induce labor. In **lactating women**, suckling causes the release of oxytocin, which targets muscle cells around the duct of mammary glands, thus promote milk ejection. **In male,** it helps to eject semen during copulation.

Median Lobe of Pituitary

It is smallest in human, made of thin layer of cells between anterior and posterior pituitary gland. It secretes **Melanocytes Stimulating Hormone (MSH).** The MSH releases due to influence of external light and more secretion during pregnancy. It stimulates melanocytes in skin and hair to produce brown pigment, the **melanin** that darkens the skin.

18.2.2 Hypothalamus

Hypothalamus is a part of fore brain, which is both nervous and endocrine. Thus it receives many sensory stimuli of the nervous system and are converted into hormonal responses. It is master control centre of endocrine system because it monitors metabolites and hormonal level in the blood. It directly controls the pituitary gland. Hypothalamus has nerve cell clusters that produce and secrete many types of hormones. One of these centres produces and secretes a variety of releasing (Tropic) and inhibiting hormone or factor. Thus act as regulatory hormones, which regulate the synthesis and secretion of other endocrine glands.

Extra Information

1. The suckling of the infants triggers the production of great amount of oxytocin, that aids in nursing process and contracts the uterus to its normal size.
2. Over secretion of oxytocin during child birth may cause rupture of uterine wall.
3. Under secretion of oxytocin inhibits normal labor process.

It has another nerve cluster which synthesizes antidiuretic hormone and oxytocin hormone, then transported and stored in posterior pituitary gland. (Table.18.1)

Table 18.1: The Function of Hypothalamus and Response with Pituitary Gland

S.No.	Hormone From Hypothalamus	Anterior Pituitary Response
i)	Growth hormone releasing factors (GHRF).	Secretion of growth hormone (GH).
ii)	Somatostatin.	Inhibits growth hormone (GH).
iii)	Gonadotrophin releasing hormone (GnRH).	Secretion of FSH, LH and ICSH.
iv)	Adrenocorticotropic releasing factor (CRF or ACRF).	Secretion of adrenocorticotropic hormone (ACTH).
v)	Prolactin inhibiting factor (PIF).	Stop secretion of prolactin.
vi)	Thyrotropin releasing factor (TRF).	Secretion of thyroid stimulating hormone (TSH).
vii)	Secretes oxytocin and ADH.	Store these hormones in posterior pituitary lobe.

18.2.3 Thyroid Gland

Thyroid gland is located at the base of neck, attached to trachea below the larynx. It is bilobed structure, butterfly-shaped and both lobes are connected by a bridge of thyroid tissue known as **isthmus**. Thyroid gland is made of spherical cells filled with three types of hormones. (Fig.18.5)

1. Tri-iodothyronine or T3 (about 10% but four time more potent than T4). It is more active in mammals .
2. Tetra-iodothyronine or T4 (about 90% thus major hormone also called thyroxin).
3. Calcitonin hormone.

Both T3 and T4 have similar structure and function, but T3 has three iodine while T4 has four iodine. The duration of action duration of T4 is four times more than T3. Their secretion is controlled by TSH from anterior pituitary gland. The T3 and T4 act on **Basal Metabolic Rate (BMR)** by stimulating the breakdown of glucose, release of heat, generation of ATP and synthesis of cholesterol in the liver.

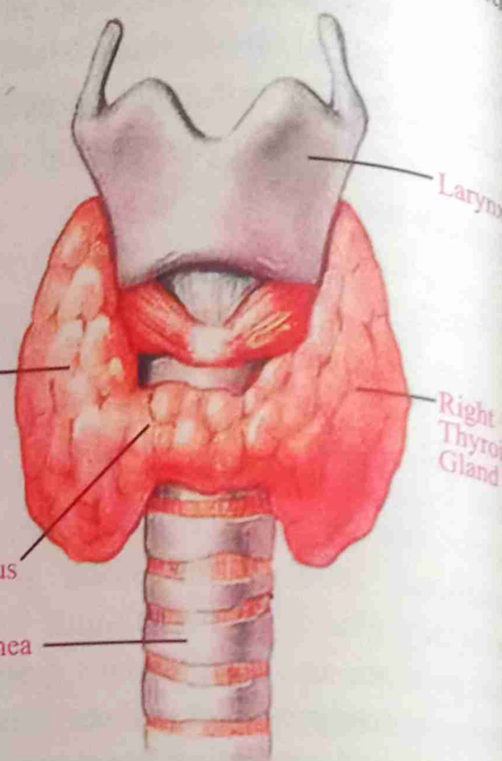

Fig. 18.5: Thyroid Gland

Thyroxin, in conjunction with Growth Hormone (GH) acts on physical growth and mental development. Thus causing them to differentiate between foetus and infant. It also promotes normal motility of the gastrointestinal tract.

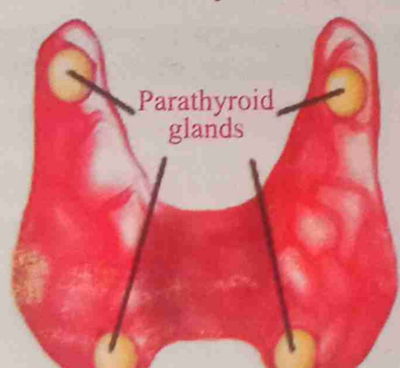

Fig. 18.6: Thyroid Gland (Back view) and Parathyroid Gland

Extra Information

Thyroxin helps in metamorphosis of tadpole to adult frog. If its concentration is less, then tadpole does not metamorphose to adult frog instead remains a large size tadpole.

Effect of Over secretion of T3 and T4 (Hyperthyroidism)

The excess secretion of thyroxin causes a condition known as **grave's disease.**

This disease causes **exophthalmic goitre** (bulging of the eye ball), which is a classical symptom of hyperthyroidism. If the patient's basal metabolic rate (BMR) increases, this can lead to cardiac failure, profuse perspiration and weight loss. It is an autoimmune disease, the blood serum of patient has abnormal antibodies to mimic TSH and continuously stimulates thyroxin release.

Effect of Under Secretion (Hypothyroidism)

The less secretion of T3 and T4 (thyroxin) causes **Cretinism, Goitre** and **Myxoedema**. Hypothyroidism may be due to absence of iodine or failure of enzyme system, which is involved in the production of thyroid hormone or due to lack of TSH.

Cretinism: In infant, less secretion of thyroxin causes dwarf condition known as **cretinism**. It is characterized by stunted growth, mental retardation, coarse facial features, coarse scanty hair, retarded sexual development.

Myxoedema: (Mean mucous swelling) In adult, low secretion of thyroxin causes myxoedema. The patient has lower metabolic rate, thickness of skin of hands, brittleness of hair and nail, intolerance to cold, mental lethargy, weight gain, low pulse rate and low body temperature (Myxoedema also called **endemic** or **colloidal goitre**).

Goitre: The deficiency of iodine causes enlargement of thyroid gland known as goitre. It is more common in mountainous areas where iodine is less in the soil or water. (Thus table salt with iodine is recommended). Thyroid gland works hard to produce sufficient amount of thyroxin. Goitre may lead to lying down of excess of fat and weight increases.

Calcitonin hormone

Thyroid gland also secretes calcitonin hormone, which plays an important role in controlling extra level of calcium ions. If calcium level rises in the blood, then it promotes the deposition of calcium in bone or prevent their reabsorption from nephrons of kidneys. It also inhibits calcium absorption by the intestine.

The **over** and **under secretion of calcitonin** leads to disturbance of calcium metabolism. Thus affects skeletal muscle (become weakened), nervous system (impulses become irregular) and blood calcium composition is disturbed, this leads to massive kidney stone.

18.2.4 Parathyroid Glands

Parathyroid glands are very small glands, which are embedded to the posterior surface of thyroid gland. They are four in number and oval in shape. Parathyroid secretes a hormone known as **parathormone**, which regulates level of calcium and phosphorous in the blood and influence gene activation. Lower calcium level of blood stimulates the parathyroid directly to increase parathormone secretion. It absorbs calcium from intestine and kidney while high level suppresses its production. (Fig.18.6)

Deficiency of Parathormone decreases blood calcium level which result excitability in nerves, muscles and convulsion. The nerves become very sensitive to stimuli, spasm and even death may occur, in case of severe deficiency.

Over Secretion of parathormone causes increase of calcium level in the blood, low phosphate concentration. It causes weakness of skeleton similar to rickets. Nerve and muscle do not response well to stimuli (movement of Ca^{++} to extracellular fluids). It increases reabsorption of Ca^{++} by the kidneys, causes massive kidney stone formation. These both conditions may be fatal. The removal of these glands causes death.

18.2.5 Pancreas: (Islets of Langerhans's)

Pancreas has both exocrine and endocrine tissues. **Exocrine tissues** secrete pancreatic juices containing digestive enzymes. The **pancreatic acinar cells** are their functional units. The endocrine clusters of cell known as **islets of Langerhans's** secrete two main types of hormones by two major types of cell i.e., **beta cells about (60%) secretes insulin** and **alpha cells about (25%) secrete glucagon hormones**, both hormones are protein in nature. The secretion of hormones is controlled by pituitary hormones STH and ACTH and responds directly to blood glucose level. (Fig.18.7)

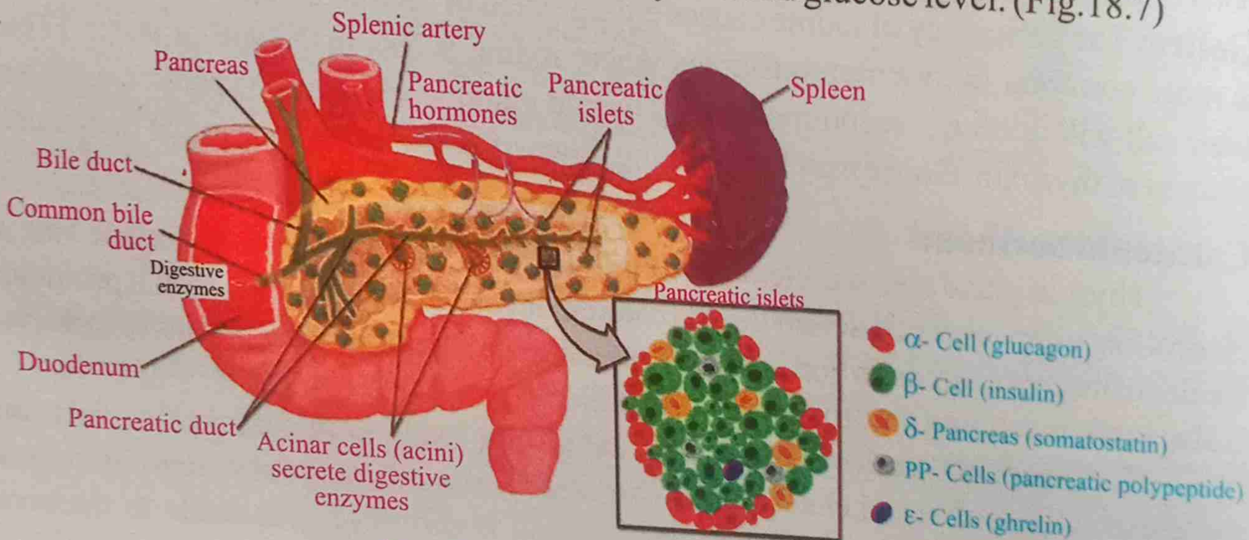

Fig. 18.7: Pancreas (Islet's Langerhans)

Insulin

The beta cells of pancreas secrete a hormone called insulin made of 51 amino acids. It is secreted when blood sugar level rises, such as after meal.

Functions of Insulin

1. It facilitates glucose transport across plasma membrane.
2. It stimulates uptake of glucose by liver, muscles and adipose tissue (fat storing cells).
3. Promotes synthesis of proteins and fats by transferring glucose.

3. Inhibits gluconeogenesis (conversion of amino acids and fats into glucose). Thus lowers blood glucose level.
4. It increases **glycogenesis** (in this process insulin converts glucose into glycogen).
5.

Glucagon

Alpha pancreatic cells secrete glucagon, made of 29 amino acids.

1. When blood glucose level decreases, glucagon converts glycogen, amino acids and fatty acids into glucose.
2. It is antagonistic to insulin.
3. Sympathetic nervous system stimulates its production.
4. It increases **Glucogenesis,** which is the process of conversion of glycogen into glucose, and, **Gluconeogenesis,** the breakdown of protein, fats and lactic acids into glucose.
5.

Disorders due to insulin deficiency

The deficiency of insulin may lead to a common metabolic disease, called diabetes **mellitus**. It causes hyperglycaemia.

Symptoms of Hyperglycaemia

1. Sugar is excreted in urine.
2. Frequent urine.
3. Abnormal thrust.
4. Rapid weight loss and weakness.
5. Drowsiness and fatigue.
6. Dehydration

Disorders due to excess of Insulin

It causes **hypoglycaemia**.

The glucose utilization increases, in turn blood fat level gets high, which upset nerve/ muscles actions.

Other types of endocrine cells in pancreas

There are three other types of endocrine cells in pancreas (about 15%) which secrete three types of hormones.

i) **Somatostatin:** It inhibits the release of gastrointestinal hormones.

ii) **Pancreatic polypeptide,** self-regulates the pancreatic secretion activities and affects the hepatic glycogen level.

iii) **Glycine act as neurotransmitter**, its deficiency may lead to type-II diabetes, increases insulin receptor in people without diabetes. It is used as supplement by type-II diabetes patients.

18.2.6 Adrenal Gland: (ad; beside, renal; kidney)

These are located on the top of each kidney, thus two in number and each with two distinct regions. **Adrenal cortex** is outer reddish brown portion. **Adrenal medulla** is inner greyish portion. Both are under the control of hypothalamus, which secretes ACTH releasing factor that stimulates anterior pituitary, which in turn stimulates the adrenal cortex. (Fig.18.8)

Hormones of Adrenal Medulla

Adrenal medulla consists of modified ganglionic sympathetic neurons, which secrete two important hormones known as **adrenaline (epinephrine)** and **nor-adrenaline (nor-epinephrine)**. Both prepare the body for stress and emergency situation *i.e.* sympathetic system. These stimulate liver cells to release glucose thus making fuel for cellular energy.

Epinephrine dilates blood vessels in the brain, heart, skeletal muscles, thus increasing alertness to overcome stress and heartbeat, breathing rate and metabolic rate increases.

Nor-epinephrine constricts blood vessels elsewhere i.e., in digestive system and peripheral vasoconstriction. It also sustains blood pressure.

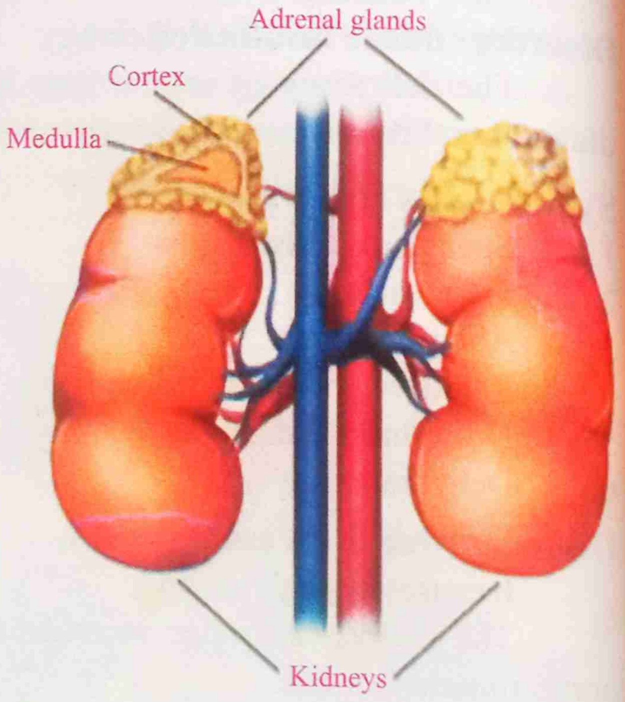

Fig. 18.8: Adrenal Glands on top of Kidneys

Disorders of Medullary Hormones

The over secretion of medullary hormones may cause hypertension and aggressive behavior during routine life while under secretion causes failure to combat with stress situation.

Hormones of Adrenal Cortex

Adrenal cortex remains active all the time, especially after shock or stress situations and infections. It secretes two major hormones.

1. **Glucocorticoids:** It regulates blood glucose level, e.g., cortisone.
2. **Mineralocorticoids:** It regulates the level of minerals in the blood, e.g., aldosterone (Collectively called corticosteroids).

Cortisone

The cortisone is involved in glucose metabolism and is produced during anxiety, fever, and disease.

It promotes the hydrolysis of muscle protein to amino acids, then amino acids to glucose.

It also helps to neutralize the inflammatory responses that leads to the pain and swelling joints in arthritis, etc. It favors metabolism of fatty acids rather than glucose, antagonistic to insulin.

Corticosterone is an example of both glucocorticoid and mineralocorticoid; it increases blood glucose level and regulates mineral ion balance.

Aldosterone promotes renal absorption of sodium and renal excretion of potassium, maintains blood volume and blood pressure.

Adrenal cortex mainly produces aldosterone. The adrenal cortex also produces small amount of male sex hormones called **androgen**, both in male and female. Sometimes tumor in adrenal cortex of female causes excess of androgens production and thus the development of certain male characteristics appear.

Disorders of Cortical Hormones

Two important diseases are caused by abnormal cortical hormones.

1. **Addison's disease**

This disease occurs by **lower secretion of corticosteroids**, which leads to general metabolic disturbances, low blood sugar level, lethargy and weakness in muscle action, loss of salts and the skin has bronze tone, and cannot overcome stress condition such as cold, heat and stress.

> ***Interesting Information***
>
> Epinephrine is sometime given through injection as an emergency treat-ment in cardiac arrest (stopping of heart beat), aphylatic shock (sun stroke) and acute asthma.

2. **Cushing's disease**

This disease occurs due to **over production of cortisol;** characterized by obesity (fat deposition on the back of neck), muscle wasting, hypertension, diabetes and due to excess protein break down muscle and bones become weak.

18.2.7 Gonads (Sex Organs)

The gonads (ovary and testes) besides gametogenesis, also secrete some important hormones.

Hormones of Ovary

The human female contains two ovaries in the abdominal cavities which secrete two important female sex hormones, estrogen and progesterone.

1. **Estrogen**

There are three types of estrogen which are almost similar in function (oestrone, oestriole and oestradiole). Estrogen is secreted from ripening follicle (in some species from interstitial cell of ovaries) and placenta under the influence of FSH from anterior

pituitary. These are steroid in nature.

Functions: The estrogen performs following functions.

1. At puberty brings about secondary sexual characters (such as rounded appearance in female due to more fat deposition, large pelvic cavity and wide hips, enlargement of accessory sex organs such as vagina, uterus, oviduct, ovary and external reproductive organs) and high pitch of voice.
2. Conception and maintenance of pregnancy.
3. Help in formation and maturation of egg.
4. At the point during estrous (animals) and menstrual cycle (human) exert a positive feedback which results in a sharp rise in LH output by the pituitary.
5. Healing of uterine wall after menstruation.
6. Prepare uterine wall to secrete proteinaceous substance for embryo.

Disorders due to deficiency of estrogen

In young female, it causes failure to mature sexually. In **adult** causes sterility while **in old women** after menopause, it's deficiency causes osteoporosis.

Disorder due to over secretion

The over secretion may lead to development of fibroids (abnormal growth) in uterus and **polycystic ovary syndrome**.

Interesting Information

Estrogen causes softness and smoothness of skin, therefore, female posse-sses softer skin than male. Estrogen is used in making face cream, soaps and shampoos *etc.*

2. Progesterone

This hormone is produced by the ruptured follicle in response of LH from anterior pituitary. The ruptured follicle becomes corpus luteum. Placenta also secretes progesterone during pregnancy.

Functions

1. Prepares uterus for implantation of fertilized ovum.
2. Promotes the development of mammary glands during pregnancy.
3. Inhibits further secretion of **FSH** (to prevent any more follicles from ripening).
4. Further thickening and vascularization of the uterus wall.
5. Used in birth control pills (to prevent ovulation).
6. Regulates secretion of gonadotropin from anterior pituitary.

Extra Information

Polycystic ovary syndrome is disorder of ovaries, numerous small collection of fluid known as follicles, which may disturb regular release of eggs, thus prolonged, frequent irregular menstrual period and level of male sex hormones increases.

Disorder due to under secretion of progesterone

The less secretion of this hormone during menstrual cycle decreases the chances

of pregnancy and may cause early menstruation. It may lead to the still birth or miscarriage.

Testes: (Male Sex Organs)

The testis in the presence of **FSH** and **ISCH** produce male sex hormones known as androgens, from their interstial cells of Leydig. There are many types of androgen, the most important of which are testosterone and 17 beta-hydroxysteroid dehydrogenase. The functions of these hormones are:

1. In fetus, androgen initiates the development of the sex organs.
2. At puberty brings about secondary sexual characters (beard, moustaches, axillary and pubic hair, voice become low pitch and spermatogenesis) and sex derives.
3. They increase secretion of sebaceous glands, sweat glands and increase sub cutaneous fatty tissue.
4. Increase metabolic activities in general.
5. Inhibit formation of female genital organs in fetus.
6. Increase **Red Blood Cells (RBCs)** production and thickness of bones.

Deficiency of androgens

It causes castration (*i.e.* secondary sexual characters do not appear in male and body looks like an immature female), thus causes male sterility.

18.2.8 Thymus Gland

This lobular endocrine gland is situated at upper part of chest behind sternum. It consists of two lobes that join in front of trachea. It is largest and more active in childhood. It is responsible for the development and differentiation of T-lymphocytes before they leave the thymus. The hormone of this gland is called **thymosin** or **thymin**.

18.2.9 Pineal Gland

It is tiny cone shaped body, located deep between the cerebral hemisphere of brain. It produces the hormone, melatonin.

Function

It is involved in a daily cycle called **circadian rhythm** (Regulated by the eyes of mammals). In many mammals, it regulates the seasonal reproductive cycle, sleep and wake cycle in human. It responds to external conditions of light and darkness as sensed through the eyes.

Role of artificially synthesized steroids in sports and their long-term effects on their users.

Steroids are artificial substances which are developed in order to do the job of testosterone. It can be classified as either anabolic or androgenic. Anabolic functions include those that promote formation of muscles, vertical growth and regulation of weight gain or loss. Androgenic refers to masculine attributes such as agility, strength and endurance. By the help of

these drugs, sportsmen can become bigger, stronger, more agile, and hence more competitive. Artificial steroids uses carry many severe health risks. Major medical problems associated with steroids include a weakened immune system, liver disease, kidney disease, high blood pressure, high cholesterol, increased risk for heart disease, blood clots, strokes, tissue damage and cancer.

18.2.10 Other Endocrine Tissues/cells

Many other hormones are also produced by organs or tissues whose function is not primarily an endocrine one, even neurons also secrete hormones.

Hormones of Gut (Gastro-intestinal Tract)

i) **Gastrin:** The hormone **Gastrin**, produced by the stomach wall, travels in the bloodstream but exerts its effect locally, stimulating the production of gastric juice (pepsinogen and hydrochloric acid). The secretion of gastrin depends on proteinaceous food in stomach when it is partially digested.

ii) **Secretin and Cholecytokinin (CCK):** These two hormones control pancreatic and liver secretion. Both are formed in the cells of duodenal wall, in response to acidic chyme, fatty and proteinaceous food.

Placental hormones

Placenta secretes hormones like progesterone, which maintains pregnancy. It also secretes estrogen, chorionic hormones, relaxin and chorionic gonadotrophin hormones. All of these facilitate in pregnancy and birth.

Hormones secreted from Kidneys

Kidneys produce some hormones such as **erythropoietin** which increases **red blood cell production.** The stimuli such as bleeding or moving to high altitudes (where oxygen is scarcer) trigger release of this hormone.

Kidney also secretes **hormone renin** which constricts arteries and monitors blood pressure, takes corrective action if it drops. It is also called **urotensin** and angiotensin.

Calcitriol: It is also secreted from kidneys and acts on the cells of the intestine to promote the absorption of calcium from the diet.

Hormones of Liver: Liver secretes a group of hormone-like compounds called **prostaglandins**. These provide protective response during infection.

Somatomedins hormone is also secreted from liver that stimulate cell growth and development.

Hormones of Brain: Enkephalins and **endorphins** are two related hormones, produced in the brain. Both bind to pain receptors and so block sensation. The enkelphalins found in thalamus and some parts of spinal cord while endorphins found in pituitary gland, in other parts of brain or distributed throughout nervous system.

Hormone of Heart: The heart secretes **atrial natriuretic hormone**, which increases sodium excretion and lowering blood pressure.

Adipose Tissues: Secretes a hormone **leptin**, which reduces appetite.

18.3 Feedback Mechanism (FBM)

It is a type of interaction in which controlling mechanism is itself controlled by the products of reactions, it is controlling. Different hormones act as a system of check and balance for each other in order to keep homeostasis. In this case two opposing systems are required *i.e.* if there is an excitatory system, there must be an inhibitory system.

18.3.1 Negative Feedback Mechanism

The type of FBM in which increase in production decreases the operation so as to stop the production of products. It stabilizes a system.

Example: If our blood glucose level becomes too high then beta cells in the islets of Langerhans respond to secrete more insulin. The insulin lowers blood glucose by converting glucose into glycogen and making body cell membranes more permeable to glucose. Thus glucose is utilized by cell and surplus glucose is stored in the form of glycogen. (Fig.18.9)

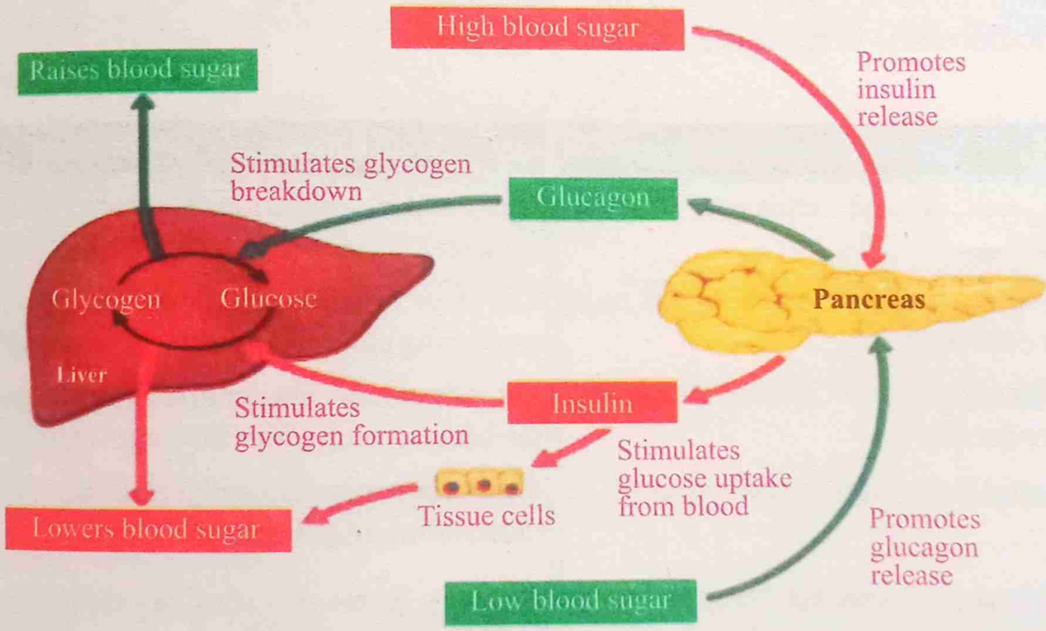

Fig. 18.9: Negative Feedback Mechanism

If the level of blood glucose gets too low, alpha cells in the islets of Langerhans secrete glucagon. It converts glycogen into glucose to raise and maintain blood glucose level. Thus the level of blood glucose is maintained by negative feedback mech-anism.

Negative feedback is most common and self-limiting.

18.3.2 Positive Feedback Mechanism

The type of FBM in which increase in production of a substance increases the operation to produce more products. It speeds up the system rather to stop it, *e.g.* Oxytocin production during labor and suckling by baby. It is rare, explosive and self-reinforcing. (Fig.18.10)

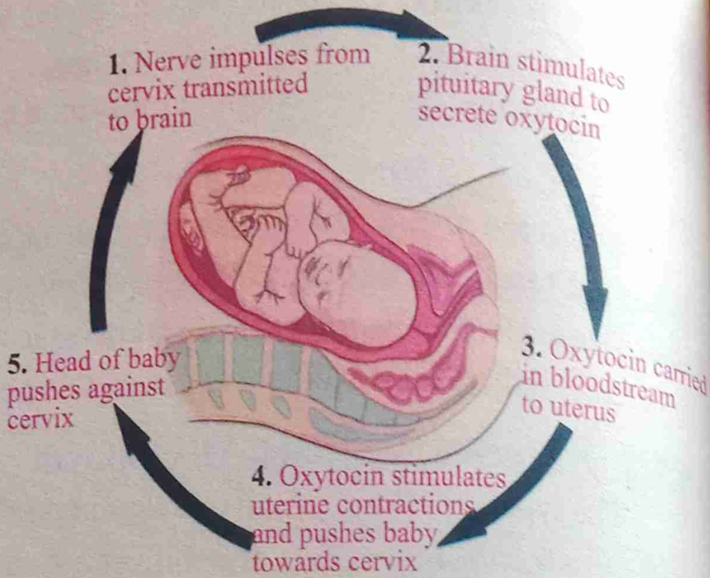

Fig. 18.10: Positive Feedback Mechanism

18.3.3 Similarities between Nervous coordination and chemical co-ordination

i) Both of these synthesize chemical messengers.
ii) Release the chemical messengers in extra cellular spaces of the body.
iii) Help in coordination of the body.
iv) Both function in response to internal or external stimuli.
v) Homeostatic in function.

Table 18.2: Differences between Nervous and Chemical Coordination

S. No.	Nervous Coordination	Chemical Coordination
i)	Electrical and chemical transmission.	Chemical transmission (hormone) through blood system.
ii)	The structural and functional units are the neurons.	The structural and functional units are hormones producing cells and neuron secretary cells.
iii)	Chemicals act where they are produced.	Hormones and neurohormones are poured into the blood which affect the target cells.
iv)	Rapid transmission and response.	Slow transmission and relatively slow acting (adrenaline an exception).
v)	Pathway is specific through nerve cells response is very localized *e.g.* one muscle.	Pathway is not specific (blood circulates whole body) target specific response may be very widespread *e.g.* growth.
vi)	Often short term changes.	Often long term changes.
vii)	The neurohormones are broken down shortly after their release.	Hormones remain active for much longer duration within the blood.